**Homework Set #5 (10 points)**

1. Read the book chapter entitled “Whaling Models for Cetacean Conservation” by Mark Boyce and answer the following questions:

Define these acronyms and explain the following terms (+0.25 each):

MSY: The long-term yield of fish to a fishery that can be sustained indefinitely (NOAA definition). MSY is defined as the biomass (abundance) level that yields the highest recruitment (N(t+1) – N(t)).

NMP: The “New Management Procedure.” In 1975, an NMP was used by the International Whaling Commission (IWC) that based harvest quotas for whales on a harvest model which had been used by fisheries. This model allowed quotas to be set for each species at levels thought to be sustainable for each species, rather than basing quotas based on blue whale units. The underlying structure of the NMP was a model based on MSY, but there were two flaws with this method: 1) There was poor or insufficient data to parameterize the model, and 2) the model may have been inappropriate due to the fact that it was a single-species equilibrium model. Additionally, inflexible management procedures within the IWC and their refusal to listen to the advice of the Commission’s Scientific Committee plagued the implementation of the NMP. And very importantly, the role of uncertainty within the model in shaping harvest quotas was not given enough attention.

RMP: The Revised Management Procedure was implemented by IWC in 1991 to manage harvested whale populations. The key aspect of the RMP was the inclusion of safeguards for exploited populations.

DT: Dt = Nt / No. The ratio of current abundance (biomass or population size, Nt) to the historical abundance (biomass or population size, No). The historical level is usually assumed to represent virgin or unexploited biomass, and explicitly labeled with the date (baseline year).

1. List the three management criteria of the RMP (+0.25 each):

The RMP has three main goals: (i) Allow recovery of depleted stocks (those below 54% of K), (ii) Maintain exploited stocks at 72% of K indefinitely, and (iii) Obtain the highest possible stable yield indefinitely.

1. Calculate the depletion (DT) for the Southern Right Whale population. Assume the current year is 1993 and use the abundance data in Table 8.1. (+0.25)

DT = NT/N0 -the original equation

DT = 3000/100000 -substitute in known values

DT = 0.03

*The depletion parameter (DT) affects the population growth in equation 1:*

**When Nt = 100% N0: (here, DT = 100% N0/N0, so DT = 1)**

Nt+1 = Nt – Ct + rNt[1 – (Nt/N0)2] -the original equation (equation 1)

Nt+1 = 100%N0 – 0 + (0.07)(100%N0)[1 – (100%N0/N0)2]

-substitute in known values

Nt+1 = 100%N0 + (0.07)(100%N0)[1 – (1)2]

-continue simplifying

Nt+1 = 100%N0 + (0.07)(100%N0)(0) -continue simplifying

*Nt+1 = 100%N0 when DT = 1, or Nt+1 = N0*

**When Nt = 50% N0: (here, DT = 50% N0/N0, so DT = 0.5)**

Nt+1 = Nt – Ct + rNt[1 – (Nt/N0)2] -the original equation (equation 1)

Nt+1 = 50%N0 – 0 + (0.07)(50%N0)[1 – (50%N0/N0)2]

-substitute in known values

Nt+1 = 50%N0 + (0.07)(50%N0)[1 – (0.5)2]

-continue simplifying

Nt+1 = 50%N0 + (0.07)(50%N0)(0.75) -continue simplifying

Nt+1 = 50%N0 + (0.0525)(50%N0) -continue simplifying

*Nt+1 = 1.0525(50%N0) when DT = 0.5* Nt+1 = 0.526N0

**When Nt = 0% N0: (here, DT = 0% N0/N0, so DT = 0)**

Nt+1 = Nt – Ct + rNt[1 – (Nt/N0)2] -the original equation (equation 1)

Nt+1 = 0%N0 – 0 + (0.07)(0%N0)[1 – (0%N0/N0)2]

-substitute in known values

Nt+1 = 0%N0 + (0.07)(0%N0)[1 – (0)2]

-continue simplifying

Nt+1 = 0%N0 + (0.07)(0%N0)(1) -continue simplifying

Nt+1 = 0%N0 + (0.07)(0%N0) -continue simplifying

*Nt+1 = 1.07(0%N0) when DT = 0. But, since 0%N0 must = 0 itself, then Nt+1 = 0.*

So in these situations, we have three different depletion parameters. When DT = 1, this means that there are no individuals being depleted from the stock, and it is thus at its carrying capacity. At this point, the population cannot grow any further (and there are no whales being taken out, as C = 0, so the final population will equal the initial population (Nt+1 = N0). When DT = 0.5, this means that 50% of the individuals of the population have been lost from the initial population. In this case, the population size actually grows by a factor of 1.0525 each year when there is no catch. Lastly, when DT = 0, this means that 100% of all individuals have been removed between the initial and final population sizes, and thus the final population is 0, and therefore there can be no population growth if there are no individuals to reproduce. Faithful application of the CLA model is one in which stock sizes end at no less than about 75% of the pre-exploitation levels (or N0).

1. Using figure 8.1, answer these questions (+0.25 each):
2. Which management approach will yield the highest catch, when the population size is 50% of the virgin abundance (unexploited population) (circle the right answer):

MSY RMP NMP All yield the same Cannot tell from data

At a 50% abundance of the unexploited population size, both RMP and NMP curtail the harvest – so the total harvest would be 0, or catch limit = 0. But, no matter what the population size, the MSY approach will always catch the same number of whales, whether or not the abundance of the unexploited population size is 60% or not.

1. Which management approach will yield the highest catch, when the population size is 100% of the virgin abundance (unexploited population) (circle the right answer):

MSY RMP NMP All yield the same Cannot tell from data

At 100% of the virgin abundance, the RMP catch limit continues to rise at a very fast rate whereas the NMP catch limit has leveled off and the MSY catch limit continues to remain at one specific value, which is not as high as the RMP catch limit at 100%.

1. Which management approach will yield the highest catch, when the population size is 54% of the virgin abundance (unexploited population) (circle the right answer):

MSY RMP NMP All yield the same Cannot tell from data

MSY is chosen once again as at 54% of the virgin abundance, the catch limits for both the RMP and NMP are at 0, as 54% is the lower limit of the stock abundance in which catch is allowed for both of those management plans. However, MSY will occur no matter what the population size, and it is definitely allows a greater take than 0 whales.

1. Which management approach will yield the highest catch, when the population size is 60% of the virgin abundance (unexploited population) (circle the right answer):

MSY RMP NMP All yield the same Cannot tell from data

1. Using the data from Table 8.1, calculate the depletion for the (DT) “global” Sei and Minke Whale populations (+0.50 each). Explain this result in light of figure 8.2, and in the context of the “competition release” hypothesis (+0.50).

Sei whale population:

DT = NT/N0

DT = 54000/256000 (\* NOTE: there was a typo in the table of the paper)

DT = 0.21, meaning that 21% of the original population remains

Minke whale population:

DT = NT/N0

DT = 725000/140000

DT = 5.18, meaning that the population has actually grown by a factor of 5.18

According to figure 8.2, the catch of Sei whales began in the mid-1920s, and was very small (near 0 caught per year) until the 1960s when it spiked up to near 20,000 per year, before dropping back down to near 0 per year again around 1974. The spike in the catch of the Sei whales follows a spike in blue whale catch and fin whale catch. It might be possible that those other 2 species had been overharvested, and fishers were moving on to another whale species, this time the Sei whale, which had not yet been harvested as much. The catch rate may have gone back down to near 0 due to the small number of remaining individuals, or the ban on whaling in 1986 may have played a role in limiting the amount of catch at that point. As explained in the figure description, it is possible that catch totals may have been under-reported, and many more whales may have been caught than what is shown in the figure, also leading to a decrease in the Sei whale population. Minke whales, on the other hand, were not caught at all until the beginning of the 1970s, and the catch has been very near 8000-9000 per year up until the late 1980s when the catch dropped down to near 0. Since the Minke whales were not caught for such a long time, it likely gave the population the opportunity to grow in size as it did (growing by a factor of 5.18).

The “competitive release” hypothesis states that if a species does not have to compete with another species, it will be able to better survive and perhaps even prosper. Before the 1960s, increased pregnancy rates and decreased age of maturity were noted in the Sei whales, possibly because they were prospering from increased krill stocks due to the depletion of blue and fin whale stocks (decreasing competition). First age to maturity has also decreased for the Minke whales since the 1930s, also suggesting the competitive release hypothesis may be important for the survival and growth of whale species populations. It has also been noted that non-whale species have also increased in abundance which also feed on krill, likely due to the decrease in competition for their food, such as crabeater seals, fur seals, and a few different penguin species. It is possible that with the harvest of the Minke whales (which have grown greatly in population size), it may release the other whale species (Sei, blue, and fin) from competition, and thus allow them to grow in size as well, which have not recovered, even with a whaling ban. YES

1. Read the paper entitled “Incorporating uncertainty into management models for marine mammals” by Barbara Taylor et al. and answer the following questions:

Define these acronyms and explain the following terms (0.25 each):

MNLP: This means “maximum net productivity level.” It is defined as the population size that would yield “. . . the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality.” So basically, it is the population size which would yield the greatest amount of population growth (in either numbers or biomass) while still subtracting out natural mortality. This was defined by the National Marine Fisheries Service in 1972 (through 1993). No kills of marine mammals were allowed if the population size dropped below MNPL, and the population would be considered “depleted” at that point. But on the contrary, no management actions were needed if the population was above MNPL. But, it difficult to calculate the level of where MNPL should be, and whether or not a population is at, above, or below that level. This concept assumes that marine mammals experience density-dependent population growth.

PBR: This stands for “potential biological removal.” The current model for marine management, part of the 1994 Amendment to the MMPA, requires that total human-caused mortality and serious injury be less than the level of PBR, using the equation: PBR = NMIN (1/2) RMAX FR, where NMIN is the population estimate, RMAX is the maximum population growth rate, and FR is the recovery factor. The basic idea behind PBR is that humans should not remove more individuals than a population needs to maintain at least half of its carrying capacity (K, either current or based on historical numbers). This management scheme helps to find populations that may be experiencing unstable mortality, and gives a target level of acceptable mortality.

FR: FR stands for the “recovery factor” as seen above within the equation for PBR. It can range between 0.1 and 1.0. This helps to remove a bias from the PBR equation. If the recovery factor is set equal to 1.0, it is assuming there is no bias in the data collected. Typically, this value is considered to be 0.5 for threatened or depleted stocks, and is considered to be 0.1 for endangered species.

OSP: This means the “optimum sustainable population level.” This was defined by the National Marine Fisheries Service as a population that is abundant enough to exceed the maximum net productivity level (MNPL).

1. List four management objectives of Marine Mammal management in the US (+0.25 each):

(1) maintain the fullest possible range of management options for future generations,

(2) restore depleted species and populations of marine mammals to optimum sustainable level with no significant time delays,

(3) reduce takes (kills) to as near zero as practicable, and

(4) as possible, minimize hardships to commercial fisheries while achieving the previous objectives.

1. Harbour porpoise in the Gulf of Maine have been estimated at Nmin = 48,285, and have a Rmax = 0.04 per year. Calculate PBR for the default scenario (Fr = 0.5) (+0.25). If the estimated mortality is 1570 porpoises per year, is this fisheries bycatch sustainable? Justify your answer by relating the observed mortality to the calculated PBR value (+0.25). Finally, figure out the Rmax that the population would need to reach to suffer no change in population size (e.g., PBR = 1570) (+0.5).

PBR = (Nmin) × (½ Rmax) × (Fr)

Nmin = 48,285 Rmax = 0.04 Fr = 0.5

PBR = (48,285)·(1/2)·(0.04)·(0.5) = 483

Because the estimated mortality (1570) exceeds the PBR (483), this bycatch is NOT sustainable.

To support this annual bycatch (1570), the annual Rmax would have to be equal to:

1570 = (48,285) \* (1/2 Rmax) \* (0.5)

Rmax = [1570 \* 2] / [48,285 \* 0.5] = 0.13

1. Define when a marine mammal population is “depleted” and “strategic” (+0.5). Think about how these two definitions require different types of data and how they provide different perspectives on the conservation status of the species. Which criterion is better suited to study bycatch impacts – why? (+0.25). Which criterion is better suited for studying competition with other species (e.g., penguins / seals) – why? (+0.25)

*Depleted:*

A marine mammal population is termed “depleted” when the population abundance falls below MNPL – the maximum net productivity level. No kills of marine mammals are allowed if the population is below this level, and no management actions are needed if the population level is above the MNPL. So, this method is based solely on the population size based on natural growth and mortality within the population, not considering the effect that human-caused mortality may have. Scientists realized that it was difficult to find MNPL for most species, so they used trends in abundance to indicate population health. But, there are 2 limitations: 1) the burden of proof is needing to prove the population is decreasing in size, and 2) low precision estimates of abundance makes it very difficult to prove the population is actually decreasing, so management actions cannot take place before the population actually has been severely depleted. Then, if a decline is noticed, it may be difficult to pinpoint what the cause of the decline was, and whether or not the decline is acceptable or not. For instance, if there was a decline of 40% (acceptable by the PBR method), it would still need to be discovered whether or not the population was continuing to decline, and what part of that decline was due to human-induced mortality.

*Strategic:*

Stocks for which estimated fishery-caused mortality exceeds PBR are considered to be “strategic.” Regulations are not necessarily imposed when fishery mortality exceeds PBR – data are instead scrutinized based on the possibility that biases can be reduced by improving abundance estimates or stock definitions. Many species once considered to be “strategic” have now been taken off the list after research was done to correct for suspected biases. But if the data is sound, and fishers are really contributing to the mortality rate, a “take reduction team” is formed which recommends means to reduce the kills to levels at or below PBR within 14 months of the finalization of the stock reports. Therefore, this approach is based on the PBR and the recovery factor.

This PBR approach is more direct than the MNPL approach because it monitors the human-caused mortality factor – the one which actually needs management. Rather than waiting for a population to be depleted to take action (like in the MNPL approach), the PBR approach reduces mortality when it is clear the current kill levels will lead to depletion. But, in order to do this, an estimate of kill must be made, which is not easy to do – gathering data is likely to be costly if the mortalities are due to a low impact by many people. Estimates are especially poor in fisheries with large numbers of small boats – a great amount of funding would be needed to cover this situation. Insufficient funding is then connected to the problem that obtaining the said funding to scrutinize private enterprise is not a very popular thing. But it is unwise to rely on reports from the resource users, and management can’t succeed without a sound estimate of the number of animals being killed, which creates a conundrum in this management method. And, obtaining measures of population structure for marine mammals is difficult in general, due to the nature of their habitat, which limits access for research. Requiring proof of population decline may make this management scheme as ineffective as the old one, simply because it may be impossible to determine the parameters necessary in order to implement this scheme.

To study bycatch impacts, it makes the most sense to use the “strategic” method, as this is the one which accounts for human-caused mortality. The “depleted” method does not account for the sources of mortality, it only uses estimates of natural population growth and decline.

On the other hand, the “depleted” method would be better for accounting competition with other species into their population model as it specifically deals with natural phenomena.